Chronic Conditions and Wearable Devices: Does the Use of Modern Technologies Improve Quality of Life in Chronic Patients

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Introduction: According to the World Health Organisation (WHO) chronic diseases are the leading cause of mortality in the world, representing 60% of all deaths. Strategies employed to tackle chronic diseases aim to act on risk factors through adopting a healthy diet, increasing physical activity and avoiding exposure to tobacco and other toxic substances. These strategies can be greatly implemented from the adoption of modern technologies, which allow a thorough and minimally invasive monitoring of patients' clinical data. Wearable electronics are defined as "devices that can be worn or mated with human skin to continuously and closely monitor an individual's activities, without interrupting or limiting the user's motions". This presentation explores the evidence obtained through a literature review, which aims to clarify whether wearable devices can help in preventing hospital readmission in chronic patients, to illustrate the types of wearable devices currently available for this purpose and whether they can contribute in improving chronic patient safety in the home care setting.
Method: A literature search of electronic databases in the healthcare field was performed in January 2017. The following databases were searched: The Cochrane Database of Systematic Reviews, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Pub Med, EMBASE and MEDLINE. In addition, an electronic and hand search of the reference lists of all the selected publications was performed to include more suitable publications. The following keywords were used: wearable devices OR wearable technology, chronic conditions OR chronic diseases, hospital admission OR hospital admission prevention OR hospital readmission OR hospital readmission prevention, elderly, safety, barriers OR obstacles OR changes.
Results: 35 qualitative and quantitative articles met the inclusion criteria and were included in the literature review. Quality assessment and data extraction were carried out and themes relating to the questions posed were abstracted for synthesis.
Discussion: Despite the large number of articles on wearable devices only few of them try to shed light on the clinical benefits of the adoption of these devices by chronic patients, since most of the papers are purely technical. Various wearable devices are currently available to monitor and keep records of different clinical information with the aim of helping users to improve their quality of life. Some of them are proved to prevent hospital re-admissions and to treat effectively life-threatening situations in certain categories of chronic patients. Higher level of acceptability and usability are achieved when users are involved in the testing stage prior to the release of the device and/or the features and terms of use are clearly described to patients and carers. In addition to the effective treatment of life-threatening conditions, wearable devices are also proved to be more accurate than clinical assessment in estimating the risk of falls in chronic patients, thus improving safety in the home care setting. Regardless of their features, wearable devices are yet to be used by both healthcare professionals and patients on a large scale. More studies need to be undertaken to understand how these useful technologies can be integrated into the healthcare system and how clinical data can be flawlessly shared among patients and healthcare professionals.

INTRODUCTION

According to the World Health Organisation (WHO, 2005) chronic diseases are the leading cause of mortality in the world, representing 60% of all deaths in 2005. Strategies employed to tackle chronic diseases aim to act on risk factors through adopting a healthy diet, increasing physical activity and avoiding exposure to tobacco and other toxic substances. These strategies can be greatly enhanced by the adoption of modern technologies, which allow a thorough and minimally invasive monitoring of patients' clinical data.

Barfield and Caudell (2001) define "wearable computer" as a "fully functional, self-powered, self-contained computer that allow the user to access information anywhere and at any time". This can be better described as "devices that can be worn or mated with human skin to continuously and closely monitor an individual's activities, without interrupting or limiting the user's motions" (Gao et al., 2017). The first device that can be considered as a wearable computer was invented by Edward Thorp and Claude Shannon in 1961 with the aim of increasing the probability of placing a winning bet when playing at roulette (Thorp, 1998). Despite its non-ethical purpose this electronic device paved the way to several other types of wearable devices that have been massively hitting the market since 2000 when Apple and Nike produced their first fitness tracking kit (De Medici, 2015).

Wearable devices currently offer the opportunity to easily measure, monitor and keep track of several clinical information such as: vital signs (hearth rate, blood pressure, temperature, respiratory rate) physical activity, sleeping patterns, diet and blood sugar (Appelboom et al., 2014). Furthermore "wearables can be networked or might store data that can be transferred later to other devices. In many cases the technology need not be activated; it simply functions as part of the item. Wearable can gather data – from the body of the wearer or from the environment – or provide information, or both" (Educause, 2013).
The aim of this literature review is to clarify whether wearable devices can help in preventing hospital readmission in chronic patients, to illustrate the types of wearable devices currently available for this purpose and whether they can contribute to improve chronic patient safety in the home care setting.
The review will be informed and based on the following questions:

1. What kind of wearable devices could be implied in preventing hospital re-admissions?
2. Are there any obstacles or barriers for patients with chronic conditions in using wearable devices on a daily basis?
3. Are wearable devices able to prevent hospital readmissions of patients with chronic conditions?
4. Can wearable devices be effectively used in improving safety in the homecare setting?

METHOD

A literature search of electronic databases in the healthcare field was performed in January 2017. The following databases were searched: The Cochrane Database of Systematic Reviews, the Cumulative Index to Nursing and Allied Health Literature (CINAHL), Pub Med, EMBASE and MEDLINE. In addition, an electronic and hand search of the reference lists of all the selected publications was performed to include more suitable publications. Publications between January 2010 and 2017 published in English were reviewed.
The following keywords were used: wearable devices OR wearable technology, chronic conditions OR chronic diseases, hospital admission OR hospital admission prevention OR hospital readmission OR hospital readmission prevention, elderly, safety, barriers OR obstacles OR changes (Bonacaro & Sookhoo, 2017).

RESULTS

Following screening of papers and quality assessment 33 qualitative and quantitative articles met the inclusion criteria and were included in the literature review. Subsequent to quality assessment, data extraction was carried out and themes relating to the questions posed were abstracted for synthesis.

What kind of wearable devices could be implied in preventing hospital re-admissions?
Several types of wearable devices are currently available to the public including healthy people, patients and healthcare professionals. In most cases one or more sensors work together to gather clinical information from patients affected by different types of medical conditions. Those sensors can be embedded in different accessories such as: headbands, sociometric badges, camera clips, smartwatches, jewels and clothes and perform various types of measurements according to the site where they are placed. According to their level of complexity and the type of sensors embedded wearable devices can monitor different functions and or activities through the measurement of several parameters such as: motion, altimetry, electrocardiogram (ECG), electroencephalogram (EEG), electromyograph (EMG), pressure, thermometer, oximeter, Bluetooth proximity, location and so on (Piwek et al., 2016).
The most common commercial wearable devices are represented by activity trackers and smartwatches which have already proved to be effective in reducing sedentary behaviour and improving total wellness (Barwais et al., 2013). Furthermore the use of wearable devices may contribute in opening up more communication channels between healthcare professionals and patients and promote a positive impact on adherence to rehabilitation (Belsi et al., 2016). Such results are achievable when the above mentioned electronic devices are wirelessly connected to a computer which is responsible to collect clinical data and share them with the appropriate healthcare professional allowing constant monitoring of the clinical situation, shared decisions and a greater sense of empowerment and self-esteem (Karapanos et al., 2016).
Wearable devices have been proving to determine positive lifestyle changes, higher quality monitoring, better communication among service users and healthcare professionals and a greater sense of empowerment and self-esteem which lead to an increase of quality of life and a reduction of hospital re-admissions.
This has also been shown in a randomised controlled trial involving patients affected by Chronic Obstructive Pulmonary Disease (COPD) where a wristband was successfully used to reduce the COPD exacerbations and related hospitalisations (Pedone et al., 2013). In fact, only 13 events leading to hospital admission where recorded in the experimental group against the 19 ones in the control one. A wrist band coupled with a cellular telephone and a commer-

cial pulse-oximeter were used in this study to monitor the hearth rate, the temperature, the galvanic skin response and the oxygen saturation in the experimental group (50 patients) while the control group (49 patients) received standard care only. The data collected were sent on a daily basis to a physician skilled in the care of respiratory patients.

Are there any obstacles or barriers for patients with chronic conditions in using wearable devices on a daily basis?
Attributes such as usability and acceptability of wearable devices are discussed in the literature according to patients', healthcare professionals' and producers' perspective. Users' usability and acceptability can be achieved by developing wearable devices around users and related stakeholders' preferences and expectations.
In fact, 2014 Abbate et al. (2014) conducted an exploratory study with the aim of measuring the usability and acceptability of a wearable monitoring system on a small group of patient affected by Alzheimer disease at an advanced stage. They concluded that not everyone easily accepts such technologies as designed by engineers. The study suggested that engineers must take into consideration users' gender at a developmental stage so that the wearable device can be easily worn and integrated as a beautiful accessory on a daily basis and collect data about target users' preferences before it can be broadly deployed.
Some studies highlight how important privacy is for wearable devices users. Despite the fact that the positive role played by wearable devices is out of discussion, the risk of privacy violation poses at serious risk their acceptability (Greenfield at al., 2016).

Are wearable devices able to prevent hospital re-admissions of patients with chronic conditions?
A limited number of articles included in this literature review intend to analyse whether or not wearable devices may prevent hospital re-admissions. The effective role of wearable devices in preventing COPD exacerbations and hospital re-admission has already been described (Pedone et al., 2013).
It can be argued that wearable cardioverter defibrillator (WCD) plays the same role by preventing the fixation of implantable cardioverter defibrillator and in some cases by delaying it while providing a safer homecare staying since no studies have been carried out on this specific focus (Mitrani et al., 2013; Erath et al., 2017). Furthermore Kutyifa at al. (2015) demonstrated that the use WCDs helps improving risk assessment in cardiac patients regarding the need for ICD implantation and exclude 40% of the participants from the already mentioned surgical procedure because of their cardiac condition improvement.

Can wearable devices be effectively used in improving safety in the homecare setting?
The effectiveness of wearable devices in improving safety in the homecare setting has been explored in different categories of patients such as: cardiac patients, patients affected by dementia, patients at risk of falls and patients affected by Alzheimer disease. The reliability and effectiveness of wearable cardioverter defibrillator (WCD) was tested in different studies to check whether or not this electronic device can ensure a safe home staying for patients with serious cardiac conditions.
Epstein et al. (2013) analysed the experience of 8453 unique cardiac patients perceived to be at high risk of sudden cardiac arrest (SCA) who used the WCD between September 2005 and July 2011. 133 patients (1.6%) received 309 appropriate shocks and 91% were resuscitated from a ventricular arrhythmia resulting in a rate of survival of 84% in nonrevascularized and 95%in revascularized patients.
Various studies assessed the role of the use of wearable devices in predicting falls with positive outcomes. Among them Greene at al. (2012) compared the use of a gyroscope with 2 standard methods in assessing falls risk in 226 community-dwelling older adults performing the 'Timed Up and Go' (TUG) test. They concluded that the use of this wearable device coupled with TUG test could lead to a robust method for assessing future falls risk.
The opportunity of effectively using a wearable device for improving home safety in patients affected by early dementia was explored by Epstein and colleagues (2016). 37 participants and 16 family care givers were recruited. The study illustrated how some participants felt controlled while their caregivers were able to control them. They both reported the monitoring system to be helpful. A larger part of the sample focused more on the importance of ensuring confidentiality and privacy as technology advances and it is spread throughout the community.

DISCUSSION

Despite the large number of articles on wearable devices only few of them try to shed light on the clinical benefits of the adoption of these devices by chronic patients, since most of the papers are purely technical. Various wearable devices are currently available to monitor and keep records of different clinical information with the aim of helping users to improve their quality of life. Some of them are proved to prevent hospital re-admissions and to treat effectively life-

threatening situations in certain categories of chronic patients.
Higher level of acceptability and usability are achieved when users are involved in the testing stage prior to the release of the device and/or the features and terms of use are clearly described to patients and carers. In addition to the effective treatment of life-threatening conditions, wearable devices are also proved to be more accurate than clinical assessment in estimating the risk of falls in chronic patients, thus improving safety in the home care setting.
Regardless of their features, wearable devices are yet to be used by both healthcare professionals and patients on a large scale. More studies need to be undertaken to understand how these useful technologies can be integrated into the healthcare system and how clinical data can be flawlessly shared among patients and healthcare professionals.

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